

# Naval Energetics Research Needs Renewed Focus

By Ashley Johnson

While other nations are making strides in energetic material development, the United States has remained dormant. The result is a surface fleet that lacks weapons with the range to attack aircraft, ships and submarines outside enemy anti-ship cruise missile range, according to one analyst.

The Navy deemphasized sea control in the 25 years since the end of the Cold War because U.S. maritime supremacy was essentially unchallenged, wrote Bryan Clark, an analyst at the Center for Strategic and Budgetary Assessments. “Less investment went into surface fleet anti-submarine warfare and surface warfare capabilities or next-generation anti-air warfare weapons.” Similarly, the Defense Department saw

no peer competitors and its energetics research and development spending dropped precipitously.

Lack of evolution in this field isn’t unique to the surface fleet. It impacts every domain of the naval enterprise: surface, undersea, air and ground. A renewed focus in energetic materials — research, development, testing and evaluation of energetics materials and systems — is required to regain the technological advantage and to provide solutions for emerging anti-access/area

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ical infrastructure program serves in a coordinating capacity in this effort, and requires the same information sharing capabilities needed by other agencies to facilitate communication and collaboration between stakeholders across the country. There are also needs for data analytics and visualization capabilities at the federal level to enable more effective decisions driven by stakeholder-provided data.

With responsibilities over areas ranging from water and food transportation to farm-specific financial systems, the food and agriculture sector is perhaps the broadest of the identified 16 critical infrastructure sectors. Consequently, responsibility is split between the Department of Agriculture — specifically the national security policy staff at the office of homeland security and emergency coordination — and the Food and Drug Administration, which is primarily involved in researching and developing food safety technologies that are critical to food and agriculture’s protection responsibilities.

Both of these agencies are heavily involved in research and development of infrastructure-protecting technologies, and industry has an opportunity to assist. Specifically, FDA’s center for food safety and applied nutrition is leading efforts to develop and disseminate new technologies that safeguard the country’s food supply, with a particular focus on responding to terrorist actions.

PPD-21 created protection mandates that extend far beyond information systems and “traditional” infrastructure.

This opens up wide swathes of the government to industry engagement, particularly around information sharing, analytics, and research support. Understanding where the pockets of protection responsibility lie, and acting on that information, will enable industry to provide real value to both the government and the American public by helping to ensure that the nation’s critical infrastructure remains safe. **ND**

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denial challenges.

Energetics are energy releasing materials — explosives, propellants, pyrotechnics, reactive materials, related chemicals and fuels — as well as their application in propulsion and ordnance systems engineered to optimize their effects. These complex materials are core to weapon development and help determine performance — range, speed, lethality and other effects. Energetic materials get weapons to the intended target, and ensure maximum lethality once they arrive.

Previous generations of these materials enabled U.S. technological superiority. Nitrocellulose propellants, Explosive D and fuzing extended naval gunfire's range and effects. Solid propellants in tough, lightweight, composite casings enabled submarine and ship-launched missiles; and thermobarics engineered for shoulder-launched munitions crumbled buildings at Fallujah.

But remaining on top requires continuous devotion, discipline, proficiency and technical rigor. Talent, novel concepts, capability and capacity are readily available within the Defense and Energy Departments, academia and industry. When there is appropriate interest and funding, new solutions are always possible. Examples include:

- Re-establishing a U.S. source of tri-amino-trinitrobenzene (TATB), an energetic material used in the booster and fuzing systems for missiles, bombs and artillery warheads. For decades, there had not been a continental U.S. source, and the United Kingdom source had not produced the material for nearly 10 years. Prior to the TATB working group's efforts, DoD had been forced to utilize stockpile material, which had been nearly exhausted.

- Developing a Lead-Azide replacement to reduce environmental concerns and meet Environmental Protection Agency requirements. The "Green Primary Explosives team" at the Naval Surface Warfare Center developed, tested and qualified an environmentally benign, drop-in replacement. The new compound is the first primary explosive qualified by the Navy in more than 90 years, and will reduce the amount of lead used in detonators and fuzes by thousands of pounds a year.

- Using microelectromechanical systems, or MEMS, to increase munitions system reliability and meet DoD

unexploded ordnance requirements. After 2018, U.S. forces will be required to employ only cluster munitions that do not result in more than one percent of them being unexploded. The Navy's early research using MEMS fuzes to reduce failure rates led to funding from the Office of Naval Research.

While these are impressive examples, they are also reactionary. For more than 15 years, the nation has accepted risk in this area by reducing research and testing investments, while others increased theirs. Today, naval energetics can make only limited contributions to advanced component development and prototypes.

"It is inconceivable that the United States should be anything but at the cutting edge of energetics," wrote former U.S. Marine Corps Commandant Gen. Michael Hagee. The inconceivable has occurred. The Navy accepted risks regarding energetic materials and systems, due to a variety of factors.

Reduced workforce was another factor. According to the naval research advisory committee's 2010 Summer Study, the naval R&D workforce dropped 50 percent in 15 years. The energetics workforce took its cuts, too. In 1994, Naval Surface Warfare Center Indian Head had 13 personnel conducting energetic material molecular design. Today, there are just four.

While the energetics workforce and research funding decreased, the naval warfare centers' workload increased 25 percent in the decade following 9/11 to meet increased operational tempo demanded by homeland security needs and the wars in Iraq and Afghanistan.

There is a misconception that rail guns and directed energy systems negate future energetics-based weapons. "By equipping ships with rail guns rather than standard artillery, the Navy could eliminate the hazards of having high explosives on board ships," stated *Scientific American*. Directed energy technology will offer tremendous capabilities. Yet there are fiscal and operational barriers, and an all-electric Navy doesn't address the host of other energetic materials systems currently out there to fight wars. Warheads, rocket motors, propulsion systems, and cartridge and propellant-actuated devices — all energetics-based — touch every part of the fleet and its wings.

Additionally, these electric weapon



**BrahMos is the world's fastest cruise missile.**

systems have no role in the underwater domain, where continued dominance should remain a high priority.

There is a misperception that energetic materials have little left to offer. Investments had dropped significantly by 2008 and continued to decline for another reason. "The consensus in the DoD scientific community is that traditional explosives and energetics performance ... has likely peaked," wrote a senior Navy official.

We are far from reaching the limit in this field as evidenced by the progress of a few internal R&D efforts:

- Densified propellants for shoulder-launched assault weapons: Due to the large overpressure produced by shoulder-launched weapon systems, they cannot safely be fired from an enclosure, requiring the operator to leave cover, increasing exposure to enemy fire.

By developing a system inspired by a recoilless rifle, this advancement will keep Marines alive by drastically reducing overpressure and fireball; reducing peak-sound, pressure-level by more than 10 decibels; and increasing impulse, or push forward, by up to 35 percent per unit volume, allowing a reduction in propulsion system size and weight.

- High-density reactive materials that replace inert steel in warhead casings: This effort significantly increases the lethality of weapon systems against an increasingly harder target set. While conventional munition casings fragment after impact, HDRM casings release additional incendiary energy to dramatically increase explosive force.



- Hybrid rocket fuel that matches solid fuel performance while creating a safer system that can be stopped and restarted in flight: The new boron-based system overcomes traditional difficulty of inefficient combustion with boron by elimination of hydrogen in the composition. The increased performance was demonstrated using a sub-scale rocket motor test stand constructed at the command.

The United States treated energetic materials and systems as a technologically frozen commodity, but other nations did not.

Development of the BrahMos missile is recounted in “The Path Unexplored” by India’s BrahMos Corp. CEO A. Sivathanu Pillai. Meeting with Russian missile developer NPO Mashinostroyeniya, Pillai said India sought a missile superior to the U.S. Navy’s Tomahawk missile. “This was to be our magical first-strike weapon,” wrote Pillai. The Russians stated they already had a liquid ramjet engine intended for a supersonic missile. A Russia-India venture resulted in reportedly the world’s fastest cruise missile, with Mach 2.8 speed and 290 kilometer range.

“Chinese scientists have become more active on the world stage in the field of energetic materials,” stated the Journal of Energetic Materials. Between 1991 and 2011, Chinese scientists published 6,415 technical papers on energetics – compared to the 5,720 published by U.S. scientists.

Such energetic materials and systems enable advanced weapons, many of which are easily available on the global

market and challenge current U.S. capabilities. Twelve surface-launched missiles outrange the U.S. Navy’s Harpoon anti-ship cruise missile. Not only longer-ranging, other nations’ ASCMs are precision guided, sea-skimming, maneuverable, and can accelerate in terminal approaches to Mach 2.9, reducing reaction times.

Now consider the future. News media reported that Russia seeks to develop a new fuel that will power Mach 5 hypersonic missiles. Documents also evidence quests for “super-cavitating” undersea weapons, with speeds of more than 200 mph — a capability greatly dependent on propellants. Additionally, Indian news broadcasts reported their country’s development of CL-20 explosive — created, but not pursued, by the United States — which is four times more powerful than standard RDX explosive.

Foreign weapon advances in multiple domains are improving and expanding.

“The combination of these rapidly-proliferating approaches permits adversaries to attack from close in or at great distance — concentrated in time and space with unprecedented precision,” wrote then Vice Adm. John Richardson and Lt. Joel Ira Holwitt in the June 2012 issue of the U.S. Naval Institute’s Proceedings magazine. “Our Navy’s traditional standoff ranges have become less and less protective.”

The challenges go beyond anti-access/area denial. Non-state actors are acquiring other nations’ advanced weapons to engage in hybrid warfare.

Deputy Secretary of Defense Robert Work recognized the implications.

“We have seen in Ukraine the state-backed proxy separatists have access to advanced capabilities. ... They’re backed by modern fire and counter-fire capability that the Army and the Marine Corps simply [have] not had to consider since the end of the Cold War,” said Work. “Our enemies have gone to school on us at least since 1991 Desert Storm, and they have adapted with a vengeance. They spent the past few decades investing heavily in capabilities that counter our own.”

While the nation has invested heavily in enhanced platforms over the past 15 years, investments in weapon systems have not maintained pace.

We can recapture technical superiority with organic, in-house talent and capability. Our naval energetics renaissance must begin now because develop-

ing the next generation of enhanced capabilities depends on a broad expanse of science and engineering disciplines that, like all things in the acquisition cycle, takes time.

This specialized work is unique to the Defense Department. Industry has minimal involvement in the field due to environmental and safety risks, long-term investments and limited commercial applications. Scientists must first conduct basic research to explore the first principles of chemistry, physics and thermodynamics. Scientists and engineers can then test hypotheses to explore concept feasibility, ultimately leading to the development, test and evaluation of prototype systems.

The 2014 Defense Innovation Initiative seeks to advance military superiority. This initiative must include a plan to increase energetic materials and systems research and testing. Warfighters are demanding weapons go farther, go faster, hit harder, have tailored effects and get smaller. The quest for smaller enables existing platforms and personnel to carry more, and accommodates miniaturized weapons being delivered by increasingly smaller, unmanned systems.

We need to address limitations of our weapon systems with respect to range, speed, size, weight, lethality, signature, accessibility and insensitivity across all domains. These calls imply requests for new weapons with new energetic materials and systems — not simply modifying weapons developed 50 years ago.

To meet these demands and fulfill our responsibilities, more subject matter experts are required. After years of cuts and attrition, there are few left and the majority of those that do remain are in the twilight years of their careers.

A 30-year naval energetics-based systems technology plan is needed for the current fleet, the fleet in construction and the fleet in planning. These fleets require state-of-the-art energetic materials and systems, initially to address capability gaps and pursue countermeasures and advantages, but ultimately to regain the nation’s full spectrum dominance against any and all potential adversaries.

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